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This paper encourages a serious look at current and future automated HF network system technology that offers great promise in overcoming the traditional problems and frustrations associated with working HF.

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Professional Notes

Tactical HF Can Get a Whole Lot Better

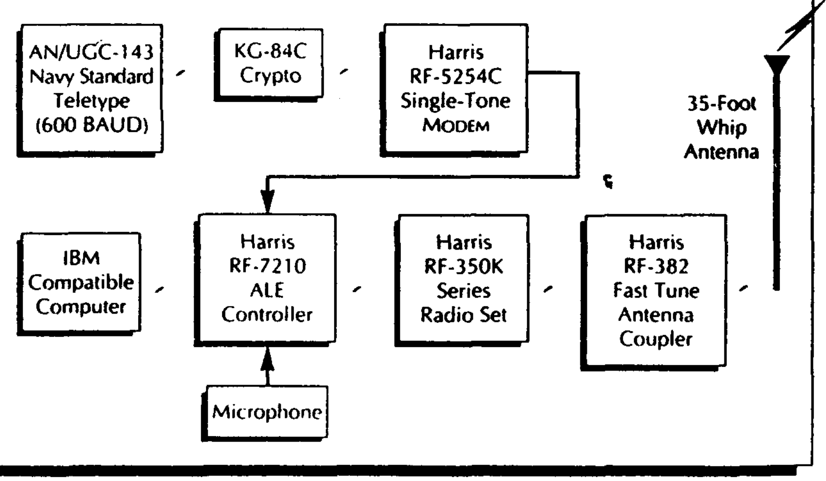
By Terry A. Danielson

A recent *Proceedings* article ["Tactical HF Enters the Skip Zone," by Lieutenant Commander M.E. Toher, U.S. Navy, April 1993, pages 109-111] encourages Navy communicators to employ near-vertical incidence sky wave (NVIS) communications techniques to provide better support to Marines engaged in littoral warfare. The author expressed longstanding concerns over declining HF (high-frequency radio) skills, and listed currently available tools and techniques for aiding in frequency selection to support NVIS. His article was particularly timely because declining defense budgets probably will slow any growth in widespread tactical satellite communications access.

I would like to go him one better and encourage a serious look at current and future automated HF technology that offers great promise in overcoming the traditional problems and frustrations associated with working HF, one of which is that the technology and techniques in use are little different from those used during the Korean War. The Navy has made some improvements in radio equipment, and there have been a few other changes for the better, but new HF technology based on microprocessors has left most of our equipment and methods quite outmoded.

New technology such as automatic link establishment (ALE) can be employed by operators to establish a channel even when all they know is each other's receive-frequency assignments.

Figure 1: USS *Tarawa* HF ALE System Block Diagram

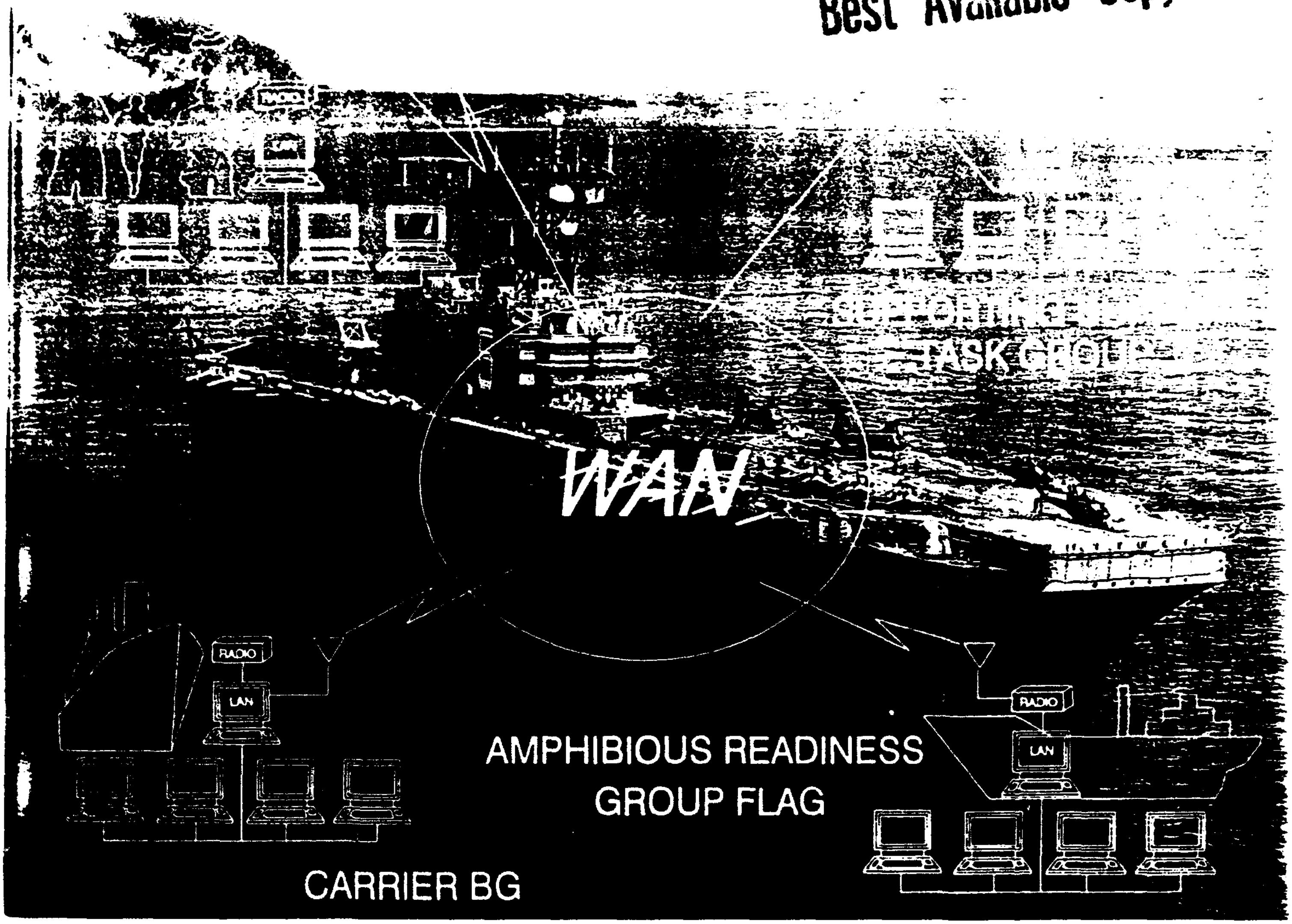


When an operator initiates an ALE call, his microprocessor-controlled radio set will attempt to establish a channel, trying each assigned frequency in turn. If the distant end hears the call and responds, a three-way "handshake" data exchange occurs, which rates the channel quality—accounting for antenna patterns, propagation, noise and interference—in about 45 seconds. If a satisfactory channel is established, the radio set controller alerts the operator, and he can begin passing traffic. The need for a separate orderwire and manual coordination of frequency shifts is eliminated. The standard version approved for military applications has other features, including a built-in operator-to-operator order-wire and memory for multiple addresses and channel assignment sets.

Powerful signal-processing modems designed specifically for high speed data transmission over the HF medium can also be exploited. The new modems use bit redundancy, bit interleaving, and error-detection-and-correction coding to reduce the effects of noise and multipath interference on the received signal. The single-tone serial modem is the most advanced presently available and, in addition to these techniques, incorporates one called adaptive channel equalization—which continuously eliminates the effect of multipath distortion. User data rates are selectable in steps up to 2,400 baud, with bit error rate performance improving as user baud rate is decreased. A specific single-tone serial waveform has been included in a military standard for HF modems.

In an effort sponsored by the Space and Naval Warfare Systems Command, the USS *Tarawa* (LHA-1) recently deployed to the Western Pacific with an ALE radio system and single-tone serial modem, and ran an on-demand HF termination with Navy shore communications sites that had been specially equipped with identical systems. Figure 1 is a block diagram of the shipboard end of the system. During her four months in the Indian Ocean and Persian Gulf, the *Tarawa* passed virtually all of her traffic over the ALE system to and from the Navy Communications Station on Diego Garcia. Messages were delivered near error-free at 600 baud with a very high channel availability. The high degree of automation also permitted the use of junior, inexperienced personnel as operators; approximately one day of training enabled them to operate the termination satisfactorily. The success of this effort has resulted in plans to continue ALE system testing from Diego Garcia with deployed amphibious ready groups.

Reduced access to satellite communications has spurred new interest in high-frequency radio for a variety of applications. The Marines and the Army are actively working on NVIS, and in the interest of joint operations, the Navy should be working closely with them. Because of inherent difficulties with HF opera-



R. KAPLAN / T. DANIELSON

A tactical high-frequency system with a wide area network could link forces ashore with forces afloat—like the USS *Peleliu* (LHA-5) lying off Iwo Jima.

tions, much higher levels of automation will be necessary if HF systems are to provide highly reliable data transfer service for the variety of present and future terminal equipments, as well as clear and covered voice. The need for automation is more apparent with expansion beyond a two station point-to-point link to a multiuser network and the goal of offering a completely automated end user to end-user service.

An ideal tactical HF system would include a wide-area network (WAN) with nodes on the beach with the Marines, offshore with amphibious ships, and more distantly with carrier battle-groups, supply ships, and perhaps an attack submarine operating in cooperation with the carrier battle group (see above). A user could send a variety of information, e.g., messages, images, graphics, files, etc., and expect near error-free delivery.

Users could pull data from on-line data bases, e.g., an updated stores listing, a battle damage assessment, or an updated tactical map. A local area net established at landing force headquarters ashore might have an HF gateway into the HF wide-area net that would tie into a local-area net on board the supporting amphibious squadron flagship, thus offering electronic mail type service. The only limitation would be channel bit rate, which is presently a maximum of 4,800 bits per second when the single tone serial waveform is stripped of error coding and redundancy (and assuming the HF channel is decent enough to support it). Operation of radios, proper addressing and routing and network management would be all be automated and would be performed by system-manager personal computers.

Creating such a net would not be simple. The hardware to support such a net is available and a few nets have been tested on a developmental basis, but none can yet support an asynchronous wide-area net approach like the one described. Such systems increase dramatically in complexity beyond a two station, point-to-point link because of concerns for "stepping" on each other's signals, blocking calls, etc. Developing controlling software for a multistation, asynchronous WAN will be a significant task.

But new developments make such a network feasible. Among them are:

▶ A family of broad-band HF radio systems, produced by Harris Corporation, which will be fully and automatically controlled from a single station and will be capable of rapid changes in operating frequencies and power levels. These fully integrated systems will support all shipboard HF transmit-and-receive circuit requirements. Initial delivery of these systems is scheduled for mid-1994 and many ships will have them by the end of the decade.

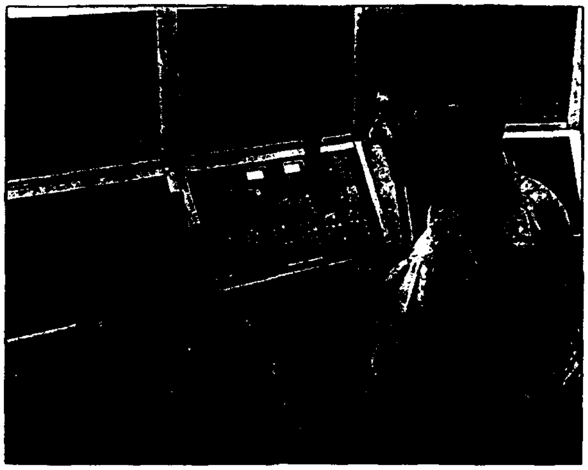
➤ A new class of U.S. government-sponsored adaptive modems, now under development, that may offer automatic adjustment of user baud rate with channel conditions to maintain an acceptable channel bit-error rate. They may also include an automatic repeat request feature to provide error-free delivery of received data.

➤ A four-node highly adaptive network, developed by Rockwell Corporation and called Smart Net, which has been demonstrated. The system provides store-and-forward features and uses a time-division multiple-access (TDMA) network in which each node is allotted a time slot for transmitting to avoid interference between signals.

➤ A fast ALE protocol, developed by Harris, that will include adaptive bit rate, power, frequency and automatic repeat request. The fast ALE assesses a half-dozen frequencies in 7-8 seconds.

These adaptive systems are generally oriented toward transmission of short messages, and are designed to maintain communications in combat. A multipurpose network will be required to pass fairly lengthy files; it may be necessary to develop a two-layer network, with network control vested in a highly adaptive system and bulk data transfer performed by a separate, more conventional ALE/single-tone serial system. When the transmitting station must operate covertly, a special link modem may be required that can transmit a low-probability-of-intercept waveform while receiving conventional signals.

A fully automated HF wide-area network would be ideal, but it may be necessary to settle in the near-term for incremental improvements in HF communications by using ALE and better modems such as those tested on board the *Tarawa*. Regardless, significant improvements in HF performance is possible now and should be pursued.



ROCKWELL INTERNATIONAL

Commercial laptop software programs such as Prop-Man (Propagation Resources Manager) recommend optimum HF skywave frequencies.

Mr. Danielson heads the Environmental and Electronics Test Branch at the Naval Command, Control, and Ocean Surveillance Center in San Diego, California. He has more than 20 years experience in HF radio communications and participated in the tests on board the USS *Tarawa* (LHA-1).

The *Inchon* Will Support Minesweeping

By Lieutenant Commander Stephen W. Surko, U.S. Navy

Operation Desert Shield/Desert Storm made clear the pressing need for a U.S. Navy mine countermeasures command, control, and support (MCS) ship. The service is studying a new-construction program, but the process of converting the USS *Inchon* (LPH-12) to serve as an interim MCS ship for a period of up to 15 years is well under way. The effort that began in January 1992 will give the Navy a near-term MCS capability to support the minesweeping fleet during distant operations.

The Navy evaluated four ship classes for conversion potential:

➤ A USS *Austin* (LPD-4)-class amphibious transport, dock

➤ A commercial Seabee-class barge carrier

➤ The carriers *Midway* (CV-41) and *Ranger* (CV-61)

➤ A USS *Iwo Jima* (LPH-2)-class amphibious assault helicopter carrier

The LPH conversion proved to be the best near-term solution, although it will not have a heavy-lift capability to transport minesweepers overseas. The *Inchon*, which is 23 years old, was selected because she is the most recently built hull of her class and is the only LPH that is fully Grade A shock qualified and not flag-configured. In addition, she was scheduled to be decommissioned in 1994, and the conversion will not affect any operating schedule. The Naval Sea Systems Command, however, has not foreclosed other options and is evaluating the USS *Newport* (LST-1179)-class for a reduced-scope conversion.

The Philadelphia Naval Shipyard, the planning yard for the LPH-2 class, was directed in September 1992 to produce a detailed in-house conversion design for the ship. An efficient reconfiguration of

Table 1: MCS-12 Principal Characteristics

Length Overall	602¢-0¢¢
Length Between Perpendiculars	556¢-0¢¢
Beam, Waterline	84¢-0¢¢
Beam, Maximum	105¢-0¢¢
Depth, Hull	77¢-3¢¢
Draft, to Keel	27¢-3¢¢
Displacement, Full Load	18,798
Installed Power, SHP	22,000 hp
Propeller Diameter	21¢-0¢¢
Electric Diameter	21¢-0¢¢
Electric Plant	(2) 2500 KW SSTGs (2) 1500 KW EDGs

Accommodations/Manning

	Officer	*CPO*	*Enlisted*	*Total*
MCS	113	80	1,227	1,420
LPH-12				
Ship	52	53	797	902
Troop	158	39	1,365	1,562

Cargo Stowage Allocations

	Area
AMCM	23,000 feet²
SMCM	6,150 feet²
EOD	3,600 feet²
Total	32,750 feet²